ADAPTING LEED CRITERIA INTO ARCHITECTURAL DESIGN TO PROVIDE A PERSPECTIVE FOR ENERGY EFFICIENCY IN AN UNDERGRADUATE DESIGN STUDIO COURSE: A CASE STUDY

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Abstract

Sustainability and energy efficiency are important notions in contemporary architecture. The necessity about creating more nature- and environment friendly places is directing architects to search for better solutions or technologies. Many different approaches and systems are being developed to provide energy efficiency in buildings and the outstretch of those approaches are becoming global with multidisciplinary and international cooperation. The mostly referred sustainability approaches are defined and systematized by the green building certification systems executed in national and international level by different institutions. Among them, USGBC’s LEED can be described as the most popular certification system as it is the most widely used one throughout the world. LEED’s sustainability strategies about reducing the greenhouse gas emission, wastewater management, passive ventilation and heating, alternative energy production and recycled material use are applicable on any architectural design and in any place of the world. Thus it creates a global guideline for architects about sustainability or energy efficiency.

Architecture education, as the foundation of the practice, needs to be in connection with the actual world of architecture to be able to provide the future architects with appropriate and sufficient knowledge. Apparently sustainability and energy efficiency issues need to be emphasized in every level of architecture education as they are key factors in contemporary architecture. The initial information and awareness about the necessity of sustainability in architecture needs to be given with theoretical courses; the information about building technologies or systems which provide energy efficiency can be introduced through architectural engineering courses, and the reflections of sustainability on the city can be examined in the urban studies. But the place where all the gathered information comes together and creates a conceptual product is the design studio which is the core of architectural education.

The selected subject of the case study in this paper is an architectural design studio for 3rd year students where the students are encouraged to create their unique energy efficiency strategies with the assistance of the conceptual framework provided by the LEED green building criteria. The main assumptions studied in this paper are that sustainability and energy efficiency in design are indispensable and important elements in the flow of an architectural design studio, and that it is an effective way to use the LEED criteria as a guideline for the development of sustainability strategies in a student project. Throughout the paper, example products of the student work from different stages of the studio are examined and as conclusion the effects of this method on the students’ vision of sustainability in architecture are discussed to create an alternative and more effective design studio course.

Keywords: architectural education, sustainable design, design studio, LEED, energy efficient design.

1 INTRODUCTION

The history of human existence on earth as intelligent beings is quite a short period of time compared with the age of the planet itself. However, its effects are extremely heavy, like none of the other species on earth. According to Yeang, What differentiates humans is their capability to force large-scale devastative changes to the environment [1]. The cognitive development of human mind and the ability to work collaboratively for the same purpose in large groups started the -until now- neverending process of consuming resources, which on the other hand can be defined as the key for the advancement of mankind. The continuum which started with the utilization of pieces of wood and stone as hunting and gathering tools has brought us to the day where huge amounts of multi-million years old fossil fuels are about to be expired. Humanity is on the edge of extinction, only partially awaken from the dream of industrial development and trying to avoid the falldown.
Architecture, the discipline responsible for the existence of any livable environment, has played its role in the regardless consumption of energy and resources, and is nowadays looking for new strategies to reduce the need for more energy, as well as supporting alternative ways to produce it. Although it is not the ultimate remedy for the mistakes done in the past, sustainable architecture can decrease further damage on the nature and resources with its reasonable methods. Using passive strategies whose foundations lie in the history of architecture as traditional and vernacular techniques, and supporting them with active systems which is provided by today’s technology, architects can make a difference in energy consumption.

The awareness on the problems about natural resources and the dedication of architecture discipline in this subject reflected on contemporary architecture with similar approaches but different definitions. “Sustainable architecture”, “ecological architecture”, “energy efficient design” and several other descriptions are all aiming for the same objective with minor varieties. The ultimate goal is, as mentioned by the Brundtland commission: to meet the needs of the present without compromising the ability of future generations to meet their own needs [2]. In the last decades the encouragement and efforts about being “green” in architecture became institutional. Governmental and non-governmental organizations were established to support sustainable and energy efficient approaches in architecture. In USA, LEED (Leadership in Energy and Environmental Design) was created by USGBC (United States Green Building Council). Great Britain’s BREEAM, Germany’s DGNB and Japan’s CASBEE are the other mostly referred green building accreditation systems. Every system has its unique mechanism and principles based on the country, but they are applicable in any place of the world. Green Building accreditation systems are beneficial in many aspects besides being supportive for energy efficient: They encourage the multi-disciplinary working process of architecture, create a conceptual framework for architectural design, support documentation and life-long tracking of buildings and they also foster the competitive nature of architects with different levels of certification.

2 ENERGY EFFICIENCY IN ARCHITECTURAL DESIGN

Presently, the world is in the middle of an energy crisis. Fossil fuels, which are the primal energy source for the human activities are expected to come to an end around the middle of the century. Causes of this can be found in the high rate of growth in population, the enhancement of building services and the very high standard of living, together with the rise in time spent inside a building [3]. Besides the search for alternative methods for energy production, it is also important to find ways of consuming the energy more efficiently. Being shaped by the emerging situations in the world, architecture sees energy efficiency as one of the main concerns of the discipline. Considering the fact that the buildings are responsible for the 40% of energy consumption in EU and USA [4], the impact of energy efficiency in architecture is extremely significant. Therefore architects have been looking for strategies which can make buildings more energy efficient. There are technological solutions which provide great benefits in energy efficiency, but technology is not the only way to deal with the energy issues. Considering the use of native and adaptive knowledge in today architecture is crucial [5]. The knowledge gained from vernacular and traditional architecture on designing in harmony with nature and immediate natural and built environment makes great use in terms of energy efficiency. Generally, the technological strategies are referred to be the active systems, and the traditional strategies are entitled as the passive systems. The optimum solution about energy efficiency and sustainability in architectural design can be achieved through the appropriate combined implication of active and passive strategies. As Hassan Fathy points out: "He (the modern architect) must renew architecture from the moment when it was abandoned; and he must try to bridge the existing gap in its development by analyzing the elements of change, applying modern techniques to modify the valid methods established by our ancestors, and then developing new solutions that satisfy modern needs."[6]

2.1 Studies on energy efficiency in architectural design

Although energy efficiency and sustainability issues are relatively recent themes in architecture, there are a large number of studies executed by academicians and professionals. Among them are Hassan Fathy with his effort for practical work on sustainable architecture in addition to his books “architecture for the poor” and “Natural energy and vernacular architecture”[7], Foster and Partners with their comprehensive case studies and technological approach to sustainable design[8] and Ken Yeang with his book called “Ecodesign: A manual for ecological design”[9] in addition to his other contributions to sustainable design approach.
Another important work on sustainable architecture is the book called “strategies for sustainable architecture” by Paola Sassi. Sassi arranges the sustainable design strategies inspired by RIBA’s key indicators for sustainability design and RIBA environmental checklist for development as follows[10]:

- **Land and ecology**
  - use of brownfield sites
  - reuse of existing buildings
  - appropriate density
  - investment in landscaping
  - public transport
  - new pedestrian routes
  - effects on micro-climates

- **Community**
  - consultation with the local community
  - mixed development
  - contribution to the economic and social well-being of the community
  - amenity of the wider area
  - visual amenity space
  - aesthetic excellence
  - collaborative enterprise involving all the design professions

- **Health**
  - comfort for building inhabitants
  - maximum use of natural light

- **Materials**
  - conservation of natural resources
  - use of recycled materials
  - low embodied energy materials
  - renewable materials from a verifiable source
  - no ozone-depleting chemicals
  - no volatile organic compound materials

- **Energy**
  - highest standards of energy efficiency
  - renewable energy sources
  - use of natural ventilation
  - use of passive solar energy
  - user-friendly building management systems
  - exploiting the constant ground temperature
  - use of planting for shading and cooling

- **Water**
  - efficient use of water
  - harvesting rainwater and greywater
  - minimising rainwater run-off

The motivation of designing energy efficiently and sustainable in the late 1990’s had also influenced groups of academicians, professionals and entrepreneurs to deal with the problem in a more corporate way. New institutions and corporations were starting to be established to develop and propagate sustainable design approach. In 1993, the United States Green Building Council was formed, followed by the Passivhaus Institut in Darmstadt, Germany in 1996. Building Research Establishment (BRE) in the UK started its certification program in 1998, which was to be referred as BREEAM in the following years. In 2000, USGBC launched the LEED (Leadership in Energy and Environmental Design) program. In 2001, Japan Sustainable Building Consortium (JSBC) established a method for evaluating and rating the environmental performance of buildings and the built environment called CASBEE (Comprehensive Assessment System for Built Environment Efficiency)[11]. Later in 2007 German Sustainable Building Council (DGNB) was founded with the aim to promote sustainable and economically efficient buildings[12]. The green building movement is getting widespread and commonly known throughout the years.

### 2.2 LEED criteria for energy efficiency in architectural design

LEED program, the green building accreditation system founded by USGBC, is nowadays the most commonly used system throughout the whole world. When in 2000 the system was firstly used, it was at a national level for the USA, but later in the following years it became worldwide. As of 2016, nearly 80,000 projects from 162 different countries participated in LEED certification [13]. The use of LEED certification system in Turkey is also quite common. According to 2015 data, Turkey is among the first 10 countries in the world in terms of LEED certifications [14]. The growing economy in the construction industry, together the rapid growth in population and the raising standards of lifestyle for the turkish society makes it necessary for the architects to be more responsive about the LEED certification system.

Since its beginning, the LEED system keeps being developed by the USGBC in cooperation with academics and professionals working in the field of sustainable architecture. At present the version 4 is in utilization and it keeps on with improvements to ensure the actuality and validity of the system. LEED certification can be implied on different types of buildings and building groups. There are a number of LEED certification types such as new construction, core and shell, schools, retail, data centers, warehouses and distribution centers, hospitality, healthcare facilities, existing buildings and neighbourhood development. Currently, the LEED system has 4 grades of certification. 40-49 points
out of 110 get a certified level; 50-59 points get a silver certificate, 60-79 points get a gold, and over 80 points get a platinum level of certification. These points are gained through the implementation of certain criteria in the design and construction phases into the building. The Criteria are divided in 9 categories:

- Location and transportation (16 credits)
- Sustainable sites (10 credits)
- Water efficiency (11 credits)
- Energy and atmosphere (33 credits)
- Materials and resources (13 credits)
- Indoor environmental quality (16 credits)
- Innovation (6 credits)
- Regional priorities (4 credits)
- Integrative process (1 credit)

All these categories are split into subcategories which offer different amounts of credits for certification. The strategies and decisions are meant to be considered in a way that makes it possible to gain the maximum amount of points offered by the design.

3 ENERGY EFFICIENCY AND ARCHITECTURAL EDUCATION

Higher education plays a significant role in the creation of a sustainable society and future. Training professionals who are aware of the importance of energy efficiency and capable of generating successful methods for sustainability is crucial and a critical process. Architecture education in particular has an even more significant role as its responsibility in the built environment is undeniable. The mutual relationship between the academy and practice in architecture makes it necessary to establish up-to-date and dynamic education contents in the schools of architecture.

The effort to implement energy efficiency and sustainability issues into the architectural education is noteworthy in the last decades. The UIA / UNESCO Charter for architectural education, created in 1996 and revised multiple times until 2011, points out that the vision of the future world, cultivated in architecture schools, should include the goal of an ecologically balanced and sustainable development of the built and natural environment including the rational utilisation of available resources [15]. This statement is supported by the 4.2.3 section in the second part of the charter where the objectives of architectural education are arranged with details. The section named “Environmental studies” states the objectives as follows:

- Ability to act with knowledge of natural systems and built environments.
- Understanding of conservation and waste management issues.
- Understanding of the life cycle of materials, issues of ecological sustainability, environmental impact, design for reduced use of energy, as well as passive systems and their management.
- Awareness of the history and practice of landscape architecture, urban design, as well as territorial and national planning and their relationship to local and global demography and resources.
- Awareness of the management of natural systems taking into account natural disaster risks. [16]

The National Architectural Accrediting Board (NAAB) in the US has also mentioned its interest about adapting sustainability and energy efficiency issues in architectural education in its “Conditions for accreditation for professional degree programs in architecture” with the statement as one of the many learning objectives: “understanding of the principles of sustainability in making architecture and urban design decisions and in the creation of healthful buildings.”[17]. RIBA in the UK signified the importance of adapting sustainability in architecture education in its validation criteria mentioning that the graduates of architecture schools should have the understanding of the impact of buildings on the environment, and the precepts of sustainable design; and the knowledge of systems for environmental comfort realised within relevant precepts of sustainable design [18].
3.1 Architecture education and LEED

The necessity of adapting sustainability and energy efficiency principles into architecture education is beyond doubt. According to “the Princeton Review’s 2009 College Hopes & Worries Survey” 66% of participating students said a college’s commitment to environmental issues would strongly or very much contribute to their assessment of the school [19]. However, the adaptation process of these issues into education requires a holistic approach to the curriculum and must be handled by the institution managements with a broad scope. In developed countries, many architectural education institutions have already passed this process successfully, so that sustainability and energy efficiency principles stand as natural components of their education concept. In developing countries on the other hand, architectural institutions are struggling to follow these innovations in education philosophy and having a difficult time to adopt energy efficiency principles into their education system as primary components. The process is highly dependent on the individual effort and determination of educators and students. To create a rapid and effective practical knowledge about sustainability issues, any kind of support which helps to concretize the notional status of sustainable design theory is beneficial for the educators in this process.

In this case LEED system provides a reliable regulation for the adaptation of sustainability issues into architectural education. As a well-known rating system, a LEED certification communicates a widely recognizable commitment to sustainability to the public, whereas the value of an uncertified “green” building’s features may be lost on those who do not have a technical background in building systems and/or sustainability [20]. The well-known brand name of LEED helps the students to materialize the concept of energy efficiency much more effectively in their minds and it helps them to create their personal pathway to sustainable design.

Another advantage of LEED system as a guideline to sustainable design is its ponderability and accountability. The system’s procedures and measures divert the designers to follow a certain path and deal with issues in different range of fields considering definite specifications. Adequate research on the particular aspects of sustainable design defined by LEED system assures the designer’s approach to be successful in those means. In their design process, the students only need to follow the pathway designated by LEED with certain criteria and measures.

4 CASE STUDY

The selected studio course for the case study is an architectural design studio for 3rd year students. The subject of the studio is a learning resources center for adults and children in a site with a loose urban context. The students are required to create an informal learning environment with respect to the existing physical and social conditions of the area. The program also includes a space for exhibitions and a conference hall. The site selected for the design problem lies in the outskirts of Istanbul. As the selected site lies in a partially rural area, there are many opportunities for energy efficiency and sustainability solutions such as alternative energy production, water management, passive climatization or daylight and sunlight use.

In the beginning of the semester, a site visit together with the whole project group has been organized. Before the site visit, a lecture about the neighbourhood and the close surroundings of the site has been given. In the site visit, the students’ attention was attracted on sustainability opportunities the site has to offer. The existing flora of the area and the river near the site have been the main features that were focused on. Transportation opportunities and traffic density of the close surroundings were also examined in the site visit and the work conducted later in the studio. Further analysis about the site was performed to understand the existing information about the topography, weather conditions, sun and wind directions and the built environment’s characteristics.

For the next phase, the students were split into groups and every group was assigned to conduct a research about a particular topic on sustainability and energy efficiency in design. The research topics were as follows:

- Site utilization & primary design principles
- Water use/management
- Active- passive ventilation & heating
- Energy use & alternative energy production
- Daylight use, artificial illumination / acoustics
Materials, resources & recycling

Every group of students was responsible for conducting a research on the assigned topic, making a presentation to the class—including the recommendation for appropriate use of the sustainability strategies for the project site—and transmitting of the presentation documents to all of the students. All the students were personally responsible for gaining the knowledge on all the 6 topics of sustainability in design. Thus the students are supplied with sufficient information on the desired subject and afterwards they are ready to imply the gained knowledge onto their design with the proper strategies.

Table 1. The students’ scoresheet for LEED criteria evaluation.

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<tr>
<th></th>
<th>Y</th>
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<th>LEED BD+C Titles</th>
<th>Possible Points:</th>
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<tbody>
<tr>
<td>1A</td>
<td></td>
<td></td>
<td></td>
<td>Bicycle Facilities</td>
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<td>1B</td>
<td></td>
<td></td>
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<td>Reduced Parking Footprint</td>
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<tr>
<td>1C</td>
<td></td>
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<td></td>
<td>Green Vehicles</td>
<td>1</td>
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<tr>
<td>2A</td>
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<td></td>
<td></td>
<td>Site Assessment</td>
<td>1</td>
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<td>2B</td>
<td></td>
<td></td>
<td></td>
<td>Site Development—Protect or Restore Habitat</td>
<td>2</td>
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<tr>
<td>2C</td>
<td></td>
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<td></td>
<td>Open Space</td>
<td>1</td>
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<td>2D</td>
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<td></td>
<td>Stormwater Management</td>
<td>3</td>
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<td>2E</td>
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<td>Heat Island Reduction</td>
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<td>2F</td>
<td></td>
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<td>Light Pollution Reduction</td>
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<td>3A</td>
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<td></td>
<td>Outdoor Water Use Reduction</td>
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<tr>
<td>3B</td>
<td></td>
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<td></td>
<td>Indoor Water Use Reduction</td>
<td>6</td>
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<td>4A</td>
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<td></td>
<td>Optimize Energy Performance</td>
<td>6</td>
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<tr>
<td>4B</td>
<td></td>
<td></td>
<td></td>
<td>Renewable Energy Production</td>
<td>3</td>
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<td>5A</td>
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<td></td>
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<td>Sourcing of Materials</td>
<td>2</td>
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<td>5B</td>
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<td></td>
<td></td>
<td>Recycling program</td>
<td>1</td>
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<tr>
<td>6A</td>
<td></td>
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<td></td>
<td>Enhanced Indoor Air Quality</td>
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<tr>
<td>6C</td>
<td></td>
<td></td>
<td></td>
<td>Thermal Comfort</td>
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<td>6D</td>
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<td>Interior Lighting</td>
<td>2</td>
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<td>6E</td>
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<td>Daylight</td>
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<td>6F</td>
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<td>Quality Views</td>
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<td>6G</td>
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<td>Acoustic Performance</td>
<td>1</td>
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TOTAL: 43

Throughout the design process, in the juries and during the 1on1 talks in the class, the importance and indispensability of being sustainable of a design has been emphasized. The students were directed to ask themselves questions such as: “How can I design my building to use daylight more efficiently?”, “What alternative energy sources can I provide my facilities?” and/or “What passive ventilation and heating strategies can I adapt into my design in order to create a sustainable building?”. The effort to answer questions similar to these made students focus more in sustainable...
strategies in design. However, experiencing difficulties in creating case-specific convenient sustainability solutions through the weeks, a risk occurred that the students were stuck in abstract phase of sustainable design strategies. In order to avoid that and create a conceptual framework for the sustainability strategies in design and to make the products of the design process more measurable, the studio course was decided to refer to the LEED criteria. A lecture about the LEED evaluation system has been given and the students were introduced to the 6 main categories and their subcategories. At a later phase of the design process students also received scoresheets so that they can evaluate their design in terms of energy efficiency and sustainability.

The scoresheet is basically a simplified version of LEED v4 for building design and construction checklist [21]. The irrelevant lines on the checklist such as the ones need to be decided before the design phase and the ones dependent on the construction phase were removed and only the lines were kept which the students can modify with their design decisions. In this way the students were also aware of their area of effect and responsibility as the designer.

3 weeks before the final submission the students were asked to evaluate their own design according to the criteria on the scoresheet and they were also allowed to make changes in their design to achieve a higher score on the evaluation. The expected results from the participant students were not only the scores they received, but also the proof of how they receive the scores according to their approach in particular parts of their design with simple sketches, notes and keywords. The total number of participated students was 30 and the average score for the energy efficiency criteria appeared to be 25.27 out of possible 43 points.

4.1 Student works

At the end of the semester, the submitted works of the students were inspected with a perspective of sustainable and energy efficient design in the framework made up by LEED criteria. The first significant feature of the submitted works was that the statements on sustainability were highly influenced by the LEED system. The definitions were much more perceptible as appeared on the scoresheet they received and the language they used on the poster presentations were highly related with the emphasis on LEED criteria in harmony with their evaluation of their own design approach. There have been some featured subjects of energy efficiency in design which provide a projection in the students’ perception of sustainability in design according to LEED criteria.

Sustainable sites

The most significant effects of LEED criteria on students’ design can be inspected on the subject of sustainable sites. In contrast to the general approach of the students where they use the biggest portion of the open space for car parking and pedestrian paths with impervious pavement, this design criteria in this study influenced them to provide reduced parking footprint, bicycle parking and storage areas, green vehicles parking and pervious pavement materials.

Figure 1. Student work sample for sustainable sites.
**Daylight use**
The use of transparent surfaces for a more effective use of daylight and sun control were other important focal points in the students’ design approach. Using horizontal and vertical, fixed and movable shading elements was the most popular method of controlling the sun where providing more transparency on the facade is beneficial for the integration of interior and exterior spaces in addition to letting daylight into the interior spaces.

*Figure 2. Sample student work for the effective use of daylight.*

**Natural ventilation**
The use of too much transparency on the building facade provokes the need for effective ventilation on the inside because of the possible greenhouse effect in the buildings. On the other hand it is also important to have a natural ventilation to create an effective use of energy sources in the building. The students tried to provide natural ventilation by creating integrated spaces on the inside with openings on the roof and higher levels of the building facade.

*Figure 3. Sample student sketch for natural ventilation.*

**Solar energy use**
The mostly referred method for alternative energy production was the use of solar panels on the roof or facade. There were two types of student behavior about this situation where in one approach students use the photovoltaic panels as shading elements in addition to alternative energy production, and in the other approach they use transparent and building integrated solar panels to provide a more transparent surface on the building.

*Figure 4. Student sketch for solar energy use.*
+ **Green roofs**

Multiple advantages of using green roofs have been emphasized frequently in different sessions and lectures, so it has been a major feature in the most of the students’ designs. The green roof’s contributions to the building’s integration with the natural surroundings, minimization of the heat island effect and effective use of rainwater were the main motivation of the students for using this feature in their design.

![Figure 5. A Student sketch for green roofs.](image)

+ **Rainwater reuse**

An important outcome in the analysis phase of the design process was that the subject region for the design has a high average of rain throughout the year. Thus the intention to make reuse of the rainwater appeared in the students’ design approach with the opinion of its contribution to the effective use of natural resources. Some of the students executed a thorough research to understand and explain the mechanisms of rainwater reuse systems and provided information about the subject in their presentations.

![Figure 6. A student’s sketch for rainwater reuse.](image)

5 **CONCLUSION**

In contemporary architecture energy efficiency and sustainability issues are indispensable components of design. During the design process these kind of requirements in a building need to be taken into account and the decisions must be made to maintain the harmony between those and other requirements of the building. Architecture education, as the foundation of the practice, must also include knowledge and skills related to sustainability and energy efficiency. The most effective way to adapt sustainability issues into architectural education is to handle the education curriculum of the institution as a whole and organize it considering the new requirements including energy efficiency.
issues. However, in developing countries like Turkey, this kind of processes of modification take more time and it cannot happen as a holistic process. Thus it becomes a necessity for academicians to put forth personal efforts for change and innovation at certain periods of education.

The subject case study in this paper is conducted with this kind of intention and the scope of the work is defined by the LEED system. LEED, as the mostly referred green building certification program, is an important part of the architecture practice and it also offers an important contribution to architectural education. The infrastructure provided by LEED is very beneficial especially for architecture design studios because it offers a large source of references and standards in different fields such as water efficiency or indoor environmental quality. Another advantageous feature of LEED is its requirement of a thorough documentation. LEED requires a number of documents from the designer in the design phase, as well as in the post-occupancy phase of the building, which strengthens the documentation discipline required in every architectural design process.

The case study proves that using LEED criteria in architectural design studios is beneficial for the students and it creates awareness on the importance of sustainable design and energy efficiency. The students’ effort to provide necessary requirements mentioned by LEED takes their design products into a higher level in the means of sustainability and energy efficiency. On the other hand it may not be overlooked that the information used in the design studios must be provided by theoretical courses and the sustainability and energy efficiency subjects need to be taught as lectures in appropriate levels. Without the necessary foundation, knowledge about the subjects provided only in architectural design courses would stay in a superficial level.

REFERENCES